Bonneville Power Administration
Fish and Wildlife Program FY98 Watershed Proposal

Section 1. General administrative information

Libby And Hungry Horse Modeling Technical Analysis

Bonneville project number, if an ongoing project 8346500

Business name of agency, institution or organization requesting funding
Montana Fish, Wildlife & Parks - Subcontract with Dr. Craig Althen

Business acronym (if appropriate) MFWP

Proposal contact person or principal investigator:

Name	Brian Marotz / Craig Althen (Contractor)
Mailing Address	490 North Meridian
City, ST Zip	Kalispell, MT 59901
Phone	(406) 751-4546
Fax	(406) 257-0349
Email address	marotz@digisys.net / althen@bewellnet.com

Subcontractors.

Organization	Mailing Address	City, ST Zip	Contact Name
Althen Enterprises	P.O. Box 413	Dumont, CO 80436-0413	Dr. Craig Althen

NPPC Program Measure Number(s) which this project addresses.
10.3A.4, 10.3A.18, 10.3B.3, 10.3B.5.

NMFS Biological Opinion Number(s) which this project addresses.
Kootenai River White Sturgeon Biological Opinion (59 FR 45989)
NMFS Hydrosystem Operations for salmon recovery (56 FR 58619; 57 FR 14653)
Bull Trout Proposed Listing (62 FR 32268) Montana westslope cutthroat, bull trout and interior redband plans.

Other planning document references.

Hungry Horse Mitigation Plan (1991); Hungry Horse Implementation Plan (1993); Libby Mitigation Plan (draft in public review phase: MFWP,CSKT and KTOI 1997); Bull trout and westslope cutthroat trout recovery actions and plans: Montana Bull Trout Restoration Team (1997); Montana Bull Trout Scientific Group (1995); MFWP and CSKT 1991, 1993; Montana Westslope Cutthroat Trout Recovery Team (draft in prep.) .

Subbasin.
Flathead and Kootenai Watersheds - Upper Columbia

Short description.
Funds subcontract with one computer programmer / modelor to perform data analyses and develop source code for new utilities, improving the reservoir / river models of Montana's Flathead and Kootenai river systems. Project costs less than $30k annually.

Section 2. Key words

Mark	Programmatic Categories	Mark	Activities	Mark	Project Types
+	Anadromous fish		Construction	+	Watershed
X	Resident fish		O & M		Biodiversity/genetics
+	Wildlife		Production		Population dynamics
	Oceans/estuaries	X	Research	X	Ecosystems
+	Climate	+	Monitoring/eval.	+	Flow/survival
	Other	+	Resource mgmt		Fish disease
		+	Planning/admin.		Supplementation
			Enforcement		Wildlife habitat en-
			Acquisitions		hancement/restoration

Other keywords.
Integrated Rule Curves, Tiered Flows, System Flood Control, Variable Discharge (VARQ), Reservoir Operation, Thermodynamics Modeling, Selective Withdrawal, Biological Modeling

Section 3. Relationships to other Bonneville projects

Project #	Project title/description	Nature of relationship
9401000	Excessive awdown Mitigation - Hungry Horse Reservoir	Compiles microhabitat and fisheries data to complement IFIM project. These data are linked to results of project 9502500 and 9101903.
9101903	Hungry Horse Mitigation - Habitat Improvements	Runs array of thermal sensors in Flathead River, provides biological and physical data from Hungry Horse Reservoir and Flathead River.

8346700	Libby Reservoir Mitigation	Provides biological and physical data from Libby Reservoir and Kootenai River, Endangered Kootenai white stugeon, and experience from completed Kootenai River IFIM project to aid Flathead IFIM project 9502500.
9502500	Flathead River Instream Flow Project	This three year project calibrates the IFIM Model that this project will link with an existing thermodynamics model from project 9101903 and biological attributes compiled by project 9401000.

Section 4. Objectives, tasks and schedules

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Create a logical procedure for duplication of the code and supporting files to facilitate the installation and use of the full-scale, quantitative models on other personal computers	a	Package the executable code to be portable and convenient for use (user friendly) to facilitate use and updating by trained personnel.
1		b	Archive methodology for data analyses used to develop the models.
2	Increase utility of models by updating graphics and reporting functions	a	Automate multiple-year simulations (batch mode) by fully integrating the executable code
2		b	Refine the hydraulic balance equations to calculate accumulated river discharge at additional points along the river course. Stations describe the three river reaches used by project 9502500.
2		c	Design a smoothing function for reshaping the annual discharge schedule, or portion there of, to create a more normal hydrograph.
3	Update the flood control relationship between Libby	a	The original hydrographic mass balance model has been updated

	Dam, Kootenay Lake, Duncan Dam and Corra Linn Dam relative to changes in the implementation of the IJC Treaty.		using records through 1997. The model will be refined to allow for additional operational strategies to reflect ongoing decision processes.
4	Test and release a simplified version of the hydraulic model for use by dam operators or system analysts	a	A new model (windows- based, Win95 and 3.1) was being tested at the time of this writing. Once tested and released, the model will accurately calculate IRC targets and tiered flows for flow augmentation.
5	Develop link between existing reservoir / river model and the IFIM based river model and upgraded thermal model	a	The existing model has a river flow and temperature component that will be upgraded by the IFIM project 9502500.
5		b	Create optimization program to facilitate user control of assumptions and variables to aid in tradeoff assessments between reservoir elevations and discharge shaping.

Objective schedules and costs

Objective #	Start Date mm/yyyy	End Date mm/yyyy	Cost %
1	10/1996	12/1999	5.00%
2	10/1996	12/1999	20.00%
3	10/1997	12/1999	20.00%
4	4/1997	6/1998	10.00%
5	4/1998	12/2001	45.00%
			TOTAL 100.00%

Schedule constraints.
Dr. Althen is planning a sabbatical in 1998-99 that will restrict the amount of time he can work on this project. Much depends on his ability to communicate with department liaisons and access computers with internet capability.

Completion date.
2001

Section 5. Budget

FY99 budget by line item

Item	Note	FY99
Personnel		$ 0
Fringe benefits		$ 0
Supplies, materials, non-expendable property		$1,000
Operations & maintenance		$ 0
Capital acquisitions or improvements (e.g. land, buildings, major equip.)		$ 0
PIT tags	# of tags:	$ 0
Travel		$1,500
Indirect costs		
Subcontracts	Dr. Althen is contracted on hourly basis	$19,000
Other	17.1 % MFWP overhead	$3,676
TOTAL		$25,176

Outyear costs

Outyear costs	FY2000	FY01	FY02	FY03
Total budget	$25,000	$25,000	$ 0	$ 0
O&M as % of total	85.00%	85.00%	0.00%	0.00%

Section 6. Abstract

This subcontract funds a part-time computer programmer / modelor needed to keep computer models of the Flathead and Kootenai River Systems up to date. These empirically calibrated, quantitative biological models estimate trophic responses due to reservoir fluctuation in Hungry Horse and Libby Reservoirs, and downstream river reaches. Thermodynamics models, simulate the operation of selective withdrawal structures installed on both dams to regulate water discharge temperature. The models also calculate the hydrologic balance at downstream projects; Kerr Dam on the outlet from Flathead Lake, and Corra Linn and Duncan Dams in the Kootenai drainage. Results were used to establish Integrated Rule Curves (IRCs) for operations at Hungry Horse and Libby and a tiered approach for flow augmentation to aid in the recovery of the endangered Kootenai white sturgeon. The IRCs and Tiered Flows were designed to balance hydropower and flood control with resident and their habitat, and to strike a balance with flow augmentation for anadromous species. A simplified hydraulic balance model (without the biological and thermodynamics components) was developed for use by dam operators or system analysts to calculate IRC targets and sturgeon flows based on

monthly inflow forecasts. The models estimate fish entrainment through Libby Dam, zooplankton entrainment through Hungry Horse, and riverine fish growth associated with thermal regulation. An IFIM-based river model nearing completion on the Kootenai, and similar work initiated on the Flathead, will be linked to the existing model framework by this project subcontract.

Section 7. Project description

a. Technical and/or scientific background.

Modeling was funded in part by the Columbia Basin System Operation Review (SOR) process 1991-1995 (SOR 1995). This project began in 1996, funding a computer modelor and minor hardware and software purchases for continued research on Integrated Rule Curves, analysis of system operation strategies for white sturgeon and salmon recovery, and to link IFIM-based river models to the existing reservoir / river models.

The models perform as living repositories for empirically derived relationships from research projects in the two subbasins. Empirical data from 1982 to 1987 were used to construct and verify to original reservoir components. Additional data from 1988 through present was used to verify relationships, extend the models downstream and add new utilities requested by operating agencies (BPA, Army Corps and Bureau of Reclamation). The models were also used to evaluate the effectiveness of selective withdrawal for temperature control at Hungry Horse Dam. Results were used during the design of the structure which was built and became functional in August 1985 (Marotz et al. 1994; Christenson et al. 1996). Flathead River temperatures now mimic the natural thermal regime.

Integrated Rule Curves were completed in 1994 (Marotz et al. 1996). The IRCs were adopted by NPPC (1994), but have not as yet been implemented because they were supplanted by operations implemented by the National Marine Fisheries Service's (NMFS) 1995 Biological Opinion (BiOp) for Snake River salmon (NMFS 1995). The two plans differed enough to warrant further comparison. Our models for Libby and Hungry Horse reservoirs were used to evaluate the biological response to various operating strategies. System models were used to examine flow augmentation in the lower Columbia and Snake Rivers. Results were used to examine resident fish concerns relative to ESA actions for anadromous fish. Wright et al. (1996) showed that the IRCs provide nearly the same flows as required for anadromous fish, as specified by the NMFS BiOp. However, the IRCs and BiOp were significantly different during the summer (late July through early September), focusing the issue. Modeling by BPA Dittmar Control Center showed that the IRCs are less costly to implement than the NMFS Biological Opinion (BiOp)(personal communication, R. Schiewe, BPA 1997). The NMFS BiOp resulted in poorer reservoir refill than the IRCs, causing negative impacts on reservoir productivity. The BiOp also caused an unnatural second peak in the Flathead and

Kootenai Rivers as storage is released to meet summer flow targets downstream (ISAB 1997). This effect is inconsistent with the Normative River Concept (ISAB 1997b). We are currently using the models to assess a gradual ramp down strategy that normalizes river flows while improving summer flows. This compromise approach was designed to balance white sturgeon requirements with salmon recovery actions and other resident fish.

The Independent Scientific Group stated, in their Return to the River document (ISG 1996), that the IRCs were consistent with their Normative River Concept and recommended that IRCs be implemented on several other storage reservoirs throughout the Columbia System. The ISAB determined that the IRC approach is a valuable tool for balancing Columbia River operation (ISAB 1997). During 1996 the tiered flow approach for white sturgeon recovery was appended to the IRC reservoir operation. The White Sturgeon Recovery Team voted unanimously to support the IRC / VARQ operation with tiered flow augmentation for sturgeon (USFWS 1997). IRCs contain a strategy for system flood control that was found to be nearly identical to the Corps VARQ strategy (ACOE 1997). Corps review of the two strategies resulted in an improvement to the IRCs to improve flood protection during high water years. The VARQ flood strategy provides more flexibility to dam operators, allowing for greater balance between the needs of resident and anadromous fish and wildlife. The B.C. Ministry of Environment has also shown interest in applying the IRC technique on Canadian storage projects.

The models produce graphic and tabular representations of inflow, reservoir surface elevation, discharge, withdrawal depth, discharge temperature, reservoir thermal structure, isopleth diagrams, daily thermographs, thermal unit summaries, carbon fixation by phytoplankton, phytoplankton washout, zooplankton production and washout by genera, benthic insect production, terrestrial insect deposition by order, monthly growth of target fish species in the reservoir by length and weight (westslope cutthroat and kokanee), discharge temperature and fish growth potential in the river. The models also provide hydrologic data at points downstream (H. Horse: Flathead Lake elevation and Kerr Dam discharge; Libby: Bonners Ferry flow for white sturgeon, Kootenay Lake elevation and inflow, Duncan Reservoir elevation and discharge, Corra Linn Dam discharge and IJC Treaty limits (IJC 1938). Additional model utilities and updates are needed to evaluate the biological effects of changing policy decisions. Examples include: international discussions regarding the operation of Canadian and U.S. projects, changing flow requests for downstream flow augmentation and updated flood control procedures.

b. Proposal objectives.

1. Archive recently acquired data sets (physical, biological, meteorological and hydrographic records) in electronic and hard-copy storage.
2. Document analyses used to build model components in open file reports, project reports and publications. Contractor provides models, data sets, user instructions for new components.

3. Improve model graphics and user utilities using statistical and graphical data analyses of annually updated records. Update model relationships representing flood control, IJC Treaty operations, and flow augmentation for white sturgeon and anadromous species.
4. After testing updated reservoir models, supply models and user instructions to interested dam operators and system analysts.
5. Develop an optimization program to link IFIM-based river models of the Flathead and Kootenai basins to the existing reservoir / river models. The link will allow user control of operational strategies for assessment of biological effects and tradeoff assessment. The new models operate in a Windows environment.

c. Rationale and significance to Regional Programs.

Headwaters remain relatively pristine and contain functioning ecosystems and species diversity that can be used as a source for repairing past damages in other areas. Today, man's activities have effected nearly all areas that are not too high, steep, wet or dry, cold or hot to develop. Pristine (wild) ecosystems have become fractionated and isolated, and as such become unstable and vulnerable to cataclysmic events (e.g. fire, flood, pollution etc.). In many areas, there is no longer a nearby reserve of a like ecotype that can protect or restock an area after a cataclysm. This makes the remaining pristine areas more valuable than ever before as living laboratories and reserves of species diversity. Hungry Horse Reservoir and upper south fork Flathead River contains an intact native species assemblage, including one of the strongest remaining populations of westslope cutthroat and bull trout. Libby Reservoir and upper Kootenai in British Columbia contains what may be the most viable metapopulations of bull trout in existence. Both drainages are inhabited by grizzly bear, mountain goats, bighorn sheep, bald eagles and many endangered plants. These areas must be recognized for their scientific and biological value. The potential for protection and restoration is high.

This project integrates the physical framework for linking related models designed to assess the biological effects of various river operations in the Flathead and Kootenai systems (Marotz et al. 1996; Skaar et al. 1996; Dalbey et al. 1998). It is a component of the larger Hungry Horse and Libby Mitigation Programs addressing operational mitigation (Integrated Rule Curve refinement and assessment: measure 10.3A and 10.3B of the FWP). This project extends and complements previous efforts in reservoir and thermal modeling (projects 9502500 and 8346700 in the Flathead and Kootenai drainages), ongoing mitigation actions (projects 9101903 and 9401000), and will provide a tool for future monitoring actions (project 9501200).

Results aid federal dam operators and fisheries managers to balance operations for the greatest benefit, balancing fisheries concerns with power and flood control. The ability to assess tradeoffs between reservoir and river operations, both locally and systemwide, is especially important now that many Columbia River fish species have been petitioned,

proposed for listing, or listed under ESA (USFWS 1994, NMFS 1995). Also, previous investments in hydropower mitigation should be protected when changes in system operation are implemented. Changes in dam operation for recovery actions in the lower Columbia have been shown to impact resident fish in the headwaters (ISAB 1997) and must be balanced to benefit all native fish species. Actions taken must also be affordable or the public will likely stop the effort. To do this, decision makers must have tools to assess tradeoffs and make wise choices.

Integrated Rule Curves are a tool to aid decision-making regarding the balance between power production, flood control and aquatic resources. The models provide a framework to compare incremental tradeoffs to resident and anadromous fish caused by various system operating strategies (beyond the SOR process). The goal is to benefit all fish from a system-wide perspective by establishing regional equity in system operations. Modeling efforts have demonstrated cooperative opportunities between NPPC, BPA, BOR, Army Corps, USFWS, State and Tribes and NMFS.

This tool is applicable to other storage projects in the Columbia System given the necessary site-specific data. Past experience has shown us how to speed the data acquisition and modeling process and reduce costs. It is now possible to qualitatively assess the biological effects of operational alternatives (i.e. develop simplified versions of IRCs) based on hydrology alone. Simplified screening models (as were used in the SOR process) can direct research efforts into the most critical areas, thus saving time and money. If this modeling technique is applied to all storage projects, will form the headwaters component(s) of an expert management program for the Columbia River system. Wet subbasins can provide a naturalized hydrograph (within flood control criteria) for anadromous species recovery, while dry subbasins a spared to protect important resident fish. Models can be used to assess tradeoffs between species or areas when plans conflict.

d. Project history

Computer modeling began in 1985 as part of research on Libby and Hungry Horse reservoirs (Marotz et al 1996)(projects 8346500 and 8346700) . Original source code for HRMOD and LRMOD were written during 1985 and 1987 in by Dr. Dan Gustafson, under direction by Dr. Daniel Goodman of Montana State University. Physical and biological data were compiled by Montana Fish, Wildlife & Parks (May et al 1988; Chisholm et al. 1989). In 1995 Rodger Ferreira calibrated the original thermodynamics model developed by Dr. Brian Adams of the U.S. Geological Survey for Flaming Gorge (Ferreira et al. 1992). Later improvements to the thermal model, including the selective withdrawal component were coded by Dr. Gustafson and Dr. Craig Althen. Dr. John Priscu of MSU consulted on the primary production component and associated field research (Dodds et al. 1989). Dr. Bill Lonon served as computer programmer during 1996 and 1997 and automated multiyear simulations and coded the tiered flow

augmentation component. The overall design of model utilities and analyses for interaction with other Columbia River system models were directed by MFWP liaison, Brian Marotz. Dr. James Anderson and Dr. Gordon Swartzman, University of Washington, performed consecutive, independent reviews of the model relationships, source code and design; their reviews lead to several improvements to the models. Skaar et al. (1996) developed a model of fish entertainment through Libby Dam that will be incorporated to the Libby model. A report on the IFIM-based Kootenai River model is in preparation by Dalbey et al. (1998). Dr. Althen was contracted to merge and update the models for use in a Windows environment. Additional refinement of model subroutines and utilities will be supported by this subcontract.

Past funding for this aspect of our program was not calculated correctly in the BPA spread sheet. Those figures include all past expenditures for the Intertie Development and Use, research and mitigation projects. Rather, the original contracts with MSU for the physical framework and biological modeling, totaled approximately $ 125,000; USGS thermal modeling $44,000; SOR contracts $25,000 each year for 3 years (funded by power supply, not FWP. We funded a fourth year through a no-cost time extension). FWP funding for FY98 totaled $33,374 (we will likely spend less than 20k this year because we began billing later than planned). Biological sampling for the models was funded under project 8346500 when it was the Hungry Horse IDU project, Hungry Horse Mitigation project 9101903, and project 8346700 on Libby Reservoir.

e. Methods.

The models are empirically calibrated component models that run using FORTRAN, Basic and C++. Models can run on a PC with appropriate memory. The modeling strategy is site-specific but the concept is portable to other reservoirs given the necessary physical and biological data. Statistics are typically non-linear regression, multivariate analyses and empirical relationships. Methods, assumptions and rationale are detailed in Marotz et al. (1996) and MFWP file reports. The statistics and model components have been critically reviewed twice by the Fishery Research Institute and Applied Physics Laboratory, Seattle (Anderson and Hinrichsen 1989; Swartzman 1996). Targeted fish species include westslope cutthroat at Hungry Horse and kokanee salmon and white sturgeon at Libby. Effects of hydro operations on trophic levels can be used to qualitatively assess non-targeted resident fish species (including bull trout, whitefish, rainbow and various non-game species).

The models require updating as new empirical evidence becomes available. A model specialist is needed to program improvements and to provide model results for various requests by BPA and other agencies. The modelor will be subcontracted by MFWP and directed by department liaisons.

1. Recently acquired data sets (physical, biological, meteorological and hydrographic records) will be archived in electronic (ASCII data files and descriptive labeling) and hard-copy storage (paper files).
2. Analyses used to build model components data sets and user instructions for new components will be documented in open file reports, project reports and publications. Model equations will be provided in computer code (updating of original code in FORTRAN, new components in C++) and mathematical equations suitable for publication.
3. Model graphics and user utilities will be updated using statistical and graphical data analyses. We typically use the simplest means to describe mathematical relationships that will make maximal use of the available data (linear or curvilinear regressions, correlations, stepwise regression, multivariate analyses, unscaled indices etc.) Updates of model relationships representing flood control, IJC Treaty operations, and flow augmentation for white sturgeon and anadromous species use hydromet data from ACOE, BPA and B.C. Hydro. Smoothing of discharge data is accomplished using the EXCEL smoothing function for running averages. We then rerun the model using the discharge/ inflow function to calculate the effect on surface elevation. The model is then rerun using the newly derived surface elevation data with the original inflow data to calculate a new discharge data set. If after review, the discharge data require further smoothing, the process is repeated; many iterations are required
4. After proofing the updated reservoir models for internal errors, we will make available copies of the models, and user instructions. Hydraulic models (minus thermal and biological components) will be available for WIN95 and 3.1 environments.
5. The optimization program that will link IFIM-based river models of the Flathead and Kootenai basins to the existing reservoir / river models, will be constructed using C++ for use in WINDOWS. The link will allow user control of operational strategies (constraints for reservoir elevations, dam discharges and river temperatures) for assessment of biological effects and tradeoff assessment

Work is part time on an “as needed” basis. Monitoring of operational changes resulting from this work will be carried out by project 9501200. Expected results were provided earlier in this document.

f. Facilities and equipment.

The Contractor will provide computer and associated equipment as part of the contract. The contract with MFWP will supply some minor equipment and support.

g. References.

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Section 8. Relationships to other projects

This project is a component of the operational mitigation program for the construction and operation of Hungry Horse and Libby Dams (MFWP and CSKT 1991,1993; and MFWP,CSKT and KTOI 1997). Measurements of physical attributes in the Flathead River influenced by Hungry Horse Dam and IFIM modeling efforts are carried out by the selected contractor under project 9502500. Biological data collection for this effort is performed by project 9401000. The thermal array in the Flathead River is monitored by project 9101903. Kootenai River monitoring and biological data collection are performed by projects 8346700 and 9401000. Thermal modeling, and modeling of reservoir

operations, and their interaction with river flows, are performed by this project. Coordination of these related projects reduces costs and expands the effectiveness of each individual project. This overall effort could be viewed as a single project, but because of differing timelines and distinct responsibilities by cooperating parties, we have separated the components for administrative purposes.

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Section 9. Key personnel

Dr. Craig Althen
Althen Enterprizes

- ***Computer Science Experience***

  Programming since 1971. Languages include: Basic (GW, Q, _A), FORTRAN (II, IV, 77, MS), C (powerC, C++, DOS Visual C++, Windows 3.1 Visual C++, Windows95 Visual C++), and various other languages, including machine language.

  Experienced with main frame, mini, and PC computers - IBM-compatible and Macintosh.

  Taught computer classes in DOS, spreadsheets, database mgmt., word processing, programming, and integrated systems.

  Expert user of analytical spreadsheets and professional database programming.

  Expert user of 3D graphics programs: NewPerspectives and AutoCad. Experienced in numerous other programs including: statistics programs, graphics programs, and various system and computer aided manufacturing programs.

  Experienced in the installation and repair of hardware and peripherals.

- ***Fisheries and Other Sciences Experience***

  Have maintained the computer simulation models used to analyze alternative operational strategies of Hungry Horse and Libby Reservoirs, periodically since 1992. Performed numerous statistical and graphical analyses on data related to Hungry Horse and Libby Reservoirs.

  Conducted or helped with a variety of field projects on both lakes and streams.

  Extensive laboratory and field work with an emphasis on advanced instrumentation: Multi-channel analysers, scintillation counters, polycorders, oscilloscopes, automated photographic systems, and chemical, limnological, meteorological, physiological and nautical instrumentation systems.

Considerable experience in statistics and mathematics.

- ***Other Experience***

  Various licenses and certificates in electro-mechanical engineering, electronics, and aviation.

  Five approved US patent applications.

  Numerous academic awards (B.A., M.S., Ph.D, Phi Beta Kappa, Who's Who in American Colleges and Universities, etc.).

  About ten years of part-time college or university teaching.

  Active in outdoor sports and travel.

- ***Other Other***

  Birth date 9-23-'42.

  Soc. Sec. No 521-56-0867.

  Married.

- ***Other Other Other***

  Non-smoker.

BRIAN MAROTZ

Fisheries Program Officer (0.0 FTE, Deparment Modeling Liaison)

490 North Meridian Road
Kalispell, Montana 59901
Phone (406) 751-4546
Fax (406) 257-0349
E-mail: marotz@digisys.net

Education

Master of Science – Fisheries Management
Louisiana State University - Baton Rouge, Louisiana.
Estuarine Biology

15 Credits: Gulf Coast Research Institute
Ocean Springs, Mississippi.
Marine Science

Bachelor of Science – Biology (Aquatic Sciences)
University of Wisconsin - Stevens Point, Wisconsin.
Freshwater Biology

16 Credits: S.E.A. Semester at Sea, Boston University
Woods Hole, Massachusetts
Marine Biology

Professional experience

1991-Present Fisheries Program Officer, Montana Fish, Wildlife & Parks
Kalispell, Montana
Duties: Supervise Special Projects Office, Hydropower Mitigation, Kootenai River IFIM project and Focus Watershed Programs.

1989 – 1991 Fisheries Biologist, Montana Fish, Wildlife & Parks
Kalispell, Montana
Duties: Hungry Horse Reservoir Research, Develop Hungry Horse Mitigation Program, Computer Modeling Flathead and Kootenai Drainages, Develop Integrated Rule Curves (IRCs) for Montana Reservoirs.

1985 – 1989 Fisheries Biologist, Montana Fish, Wildlife & Parks
Libby, Montana
Duties: Libby Reservoir Research, Kootenai Instream Flow Project, Computer Modeling Flathead and Kootenai Drainages, Develop Integrated Rule Curves (IRCs) for Montana Reservoirs.

1984 – 1985 Research Associate, Louisiana State University - Baton Rouge, Louisiana
Duties: Estuarine Research to control salt water encroachment to Estuarine Marsh on the Sabine National Wildlife Refuge. Developed Operating Plan for Water Control Structures to Allow Migration of Catadromous Fish and Crustaceans

Publications

Pertinent Publications Listed in this Document

Awards

1994 Governor's Award for Excellence in Performance as an Employee of the State of Montana

1994 Director's Award for Excellence as an Employee of Montana Fish, Wildlife & Parks

1989 Certified Fisheries Scientist
American Fisheries Society

Section 10. Information/technology transfer

The Contractor report will be submitted to MFWP and BPA. Project results will be published in BPA reports and, where applicable, peer reviewed journal articles. Monthly or quarterly reports will be available to all agency and citizen groups.